TRACKING RATE

MK I HAND CONTROL

JANUARY 1957
Prepared for Contract SC 21-54

DRIFT SIGHT TRACKING ACCURACY

INTRODUCTION

During the weeks of November 12th and November 26th, 1956 extensive tests were conducted at the Ranch to determine the tracking rate accuracy of the MK I Hand Control and Drift Sight (mechanical unit).

EQUIPMENT

Earlier tests both in the field and in the laboratory resulted in the following reworking of Hand Control and Drift Sight parts:

(a) The flexible control cables were rerouted in the aircraft to minimize sharp bends.

(b) Residual oil in the flexible cables made them stiff at low temperatures. New flexible cables, free of oil were installed and used for the tests.

(c) Lubricating oils in the Drift Sight head scanning mechanism were carefully selected and sparingly used to eliminate any stiffness at low temperatures.

(d) Backlash in the gear train of the Hand Control was minimized by inserting spring take-up on some gear meshes. Backlash was minimized also by redesigning the boresight adaptors to eliminate a bevel gear mesh.

(e) A new reticle was installed which had a center break cross hair at the optical center of the Drift Sight.

(f) Tolerances increased for differential in temperature coefficient of expansion of metals.

TEST METHOD

A test program entitled "Drift Sight Test Program A" dated November 8, 1956 was used for coordinating the tests conducted. A copy of this program is attached. In place of the Century recorder an accurate Wheatstone bridge was furnished the pilot to measure the value of the IMC potentiometer setting in the Hand Control. This measured setting was compared with computations made from the negatives taken. Throughout these tests the vehicle's auto-pilot was used.

ANALYSIS

The time base for measurements on the negatives was established by examining the recorded clock sweep second hand and further by averaging the time for a large number of frames. In these tests the camera intervalometer proved stable and yielded a frame interval of 15.00 seconds.

There were a total of ten useful sets of information from the two missions flown. Table I gives the tracking rate error (difference between computations from film and setting of the Hand Control's. IMC potentiometer) as the average error for the duration of the time interval.

TABLE I

Frame Nos.	Total Time Interval (Secs)	Rate Error (Milrad/Sec)
150-164	210	-.04
226-233	105	∤ 1.5
259-265	90	-.7
133-139	90	∤.1

127-134	105	-.75
175-186	165	±.125
202-208	90	-.395
252-260	120	-.63
302-306	60	-.506
345-353	120	-.381

The above data is plotted as a graph in figure 1.

The allowable error is ± .3 milrad/sec to ± .6 milrad/sec for the C Configuration, depending upon the shutter speed.

In order to take advantage of the considerable number of tests run the RMS errors for aircraft and for the Hand Control were computed. The values were as follows:

RMS error in aircraft motion	± 1.37 mr/sec.
RMS error of aircraft plus Hand Control	1.66 mr/sec.
Resultant RMS error of Hand Control alone	.926 mr/sec.

Further analysis of the film data showed, in the case of the 210 second test run that the aircraft motion was:

75 foot altitude variation (porpoising) in 40 seconds.

This is equivalent to an image motion in the viewfinder of 15 mils (angular) or ¼ the recticle square. This is quite a small motion and would not warrant stabilization.

An error of .3 mr/sec. is equivalent to motion of an object in the viewfinder of ½ the reticle square in 144 seconds (ie 60° angular sweep at nominal IMC rates).

Despite these values the test runs show that the pilot permitted the object to move 1½ reticle squares without making corrections. The con-

clusion then is: more pilot training is required to yield the accuracy inherent in the system and required by the C Configuration.

A tabulation of each of the test points, as derived from measurements on the various film frames is included in Appendix I. The second column of this tabulation is the actual IMC rate of the aircraft over the fifteen second interval. A plot of these values for frames 150 to 164 appears in figure 2.

ERRORS IN TEST METHOD

The values given in Table I are overall system errors and include:

(a) Test instrumentation error.

(b) Pilot error in setting tracking rate.

(c) Vehicle motion in pitch, roll and yaw.

The test instrumentation error rests primarily in the accuracy of the Wheatstone bridge used in measuring the IMC potentiometer. The bridge is accurate to $\pm$ .1% which is equivalent to an error in IMC of $\pm$ .012 mr/secs.

The error in computation of IMC rate from film data is $\pm$ .6% of the nominal IMC rate (which was 9 to 10 mr/sec).

Pilot error in setting the tracking rate is a human error which is difficult to evaluate and one which will always be present in the system. Training and experience can minimize it but not eliminate it.

CONCLUSION

The Hand Control and Drift Sight are capable of yielding tracking rate settings which are within the $\pm$ .3 mr/sec error allowable in the system composed of Drift Sight, aircraft, pilot and C Configuration. Proper cable routing, degreased cables and scanning head and adequate pilot training will permit this accuracy to be maintained.

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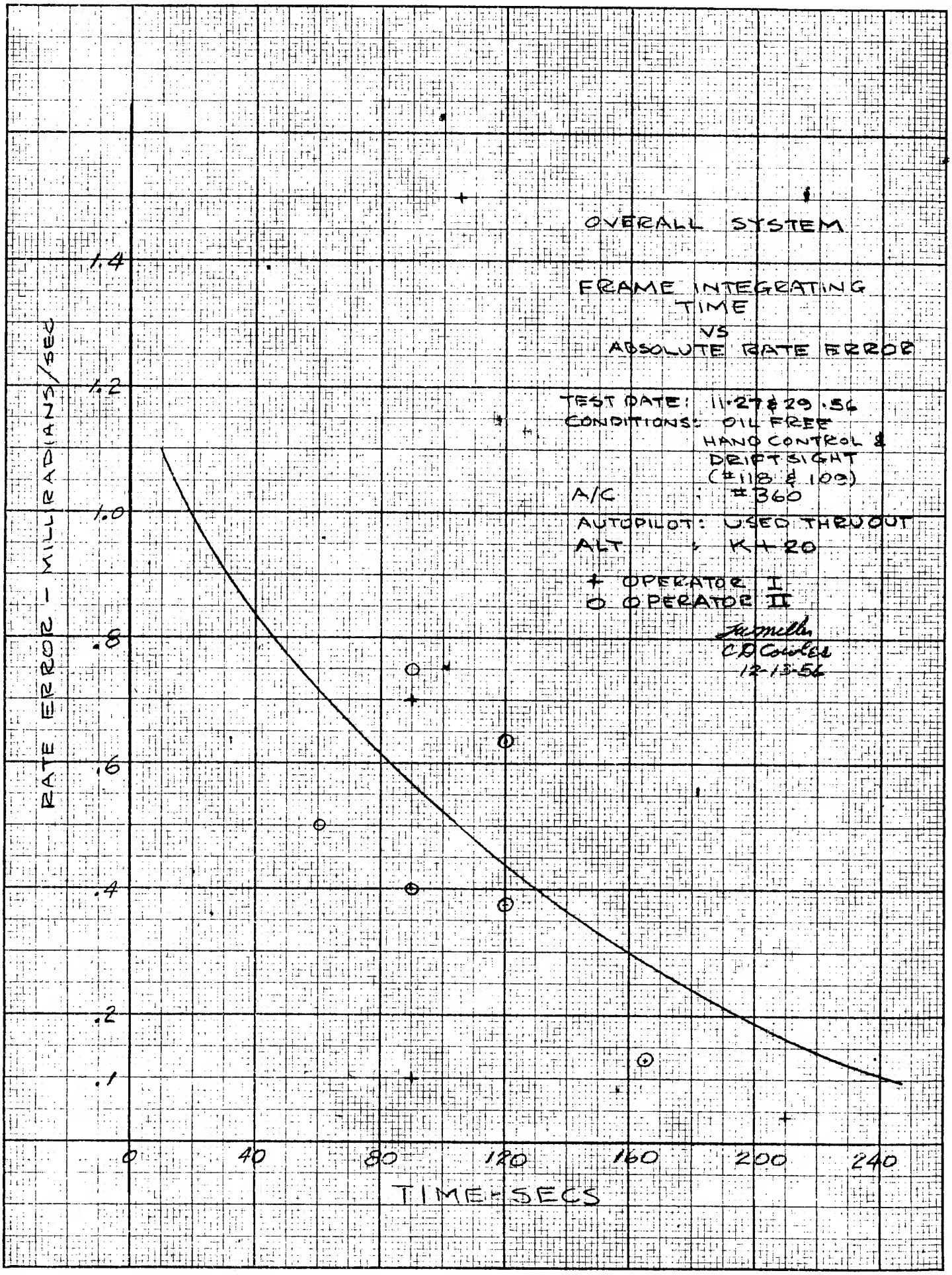

FIG 1

APPENDIX I

FRAME NOS.	DEVIATION FROM AVG. MR/SEC	MR/SEC RATE FROM NEG.
150-151	.37	9.64
151-152	∤ .39	10.4
152-153	- .644	9.366
153-154	- .551	9.459
154-155	∤2.29	12.30
155-156	-2.23	7.78
156-157	∤ .78	10.79
157-158	∤ .136	10.146
158-159	- .993	9.017
159-160	-1.14	11.15
160-161	∤ .61	10.62
161-162	∤ .26	10.27
162-163	- .26	9.75
163-164	- .551	9.459
226-227	- .1	11.2
227-228	- .6	10.7
228-229	∤1.6	12.9
229-230	∤1.4	12.7
230-231	-3.0	8.3
231-232	-2.0	9.3
232-233	∤2.6	13.9
259-260	∤1.552	10.681
260-261	- .731	8.398
261-262	∤ .666	9.795
262-263	∤ .844	9.973
263-264	∤ .168	8.961
264-265	-2.163	6.966
133-134	∤ .68	10.5
134-135	-1.12	8.7
135-136	- .48	10.3
136-137	∤1.38	11.2
137-138	- .27	9.58
138-139	- .12	9.70
127-128	- .019	9.693
128-129	.291	10.003
129-130	.201	9.913
130-131	1.768	11.48
131-132	- .559	9.153
132-133	- .832	8.88
133-134	- .846	8.866

FRAME NOS.	DEVIATION FROM AV. MR/SEC	MR/SEC RATE FROM NEG.
175-176	- .702	9.833
176-177	.495	11.03
177-178	- .005	10.53
178-179	- .935	9.60
179-180	.018	10.553
180-181	1.638	12.173
181-182	.345	10.88
182-183	.111	10.646
183-184	-3.109	7.426
184-185	.325	10.86
185-186	1.818	12.353
202-203	.436	11.278
203-204	-1.582	8.260
204-205	.104	9.946
205-206	2.867	12.709
206-207	.157	9.999
207-208	-2.986	6.859
252-253	-1.611	7.823
253-254	-2.517	6.917
254-255	.183	10.617
255-256	-1.685	7.749
256-257	1.169	10.603
257-258	- .339	9.095
258-259	.355	9.789
259-260	3.446	12.880
302-303	- .429	9.164
303-304	2.228	11.821
304-305	.739	10.332
305-306	-2.539	7.054
345-346	- .498	9.863
346-347	1.283	11.644
347-348	.142	10.503
348-349	-1.592	8.769
349-350	1.160	11.521
350-351	1.454	11.815
351-352	-1.332	9.029
352-353	- .613	9.748